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GEOLOGY

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Introduction

This project is not designed to train you as a geologist, but it will introduce you to some of the materials studied by geologists and will, hopefully, give you an appreciation and understanding of some of the elements of earth science. You will be exposed to some new words, too. As you go along, use your dictionary or other references to find out what these words mean. This manual contains very little of the information needed to do the projects. That information has been covered well in other books, and we have not duplicated it here. You will find the titles of several references listed below.

No single publication is adequate to describe all rocks and minerals. You may have substantial problems in identifying rocks, especially those combining such a variety of characteristics that they defy the most professional "eye ball" identification. Do not be discouraged! Do the best you can! Remember, even machines costing hundreds of thousands of dollars have difficulty with some!

Many minerals will not be discussed, and you will not be expected to know about them because they are too complex to be considered within the scope or age group of this program.

WHAT DO I DO?

Start by looking through this manual. You will see that it consists of three sections:

1. HOUSEHOLD MINEROLOGY
2. ROCKS AND MINERALS
3. LAPIDARY WORK

We have tried to make the exercises within each section increasingly difficult and challenging. Find one that interests you and begin there.

You will need one reference book: ROCKS AND MINERALS--Golden Book series by Herbert S. Zim and Paul R. Shaffer. We suggest that you buy this book at your local bookstore or drugstore. If you cannot find one, write to Bookstore, Coffey Hall, Institute of Agriculture, Forestry and Home Economics, St. Paul, Minnesota 55108. Enclose $1.50 plus tax and postage.

There are usually many adults in each county who are interested in geology. Many counties have active lapidary clubs. If you do not belong to a 4-H geology club or geology project group and are studying this project on your own, consult with your county extension agent about a project advisor. He may be able to find someone to advise and help you in this project.

REFERENCES

ROCKS AND MINERALS by Zim and Shaffer is one of a series of Golden Books and is most valuable to the beginner. A great variety of material is discussed and the many color illustrations are very good. For $1.50, it provides an absolute maximum of information. It is available at most bookstores and on many magazine racks in local drugstores.

Publications of the Minnesota Geological Survey--a 14-page free catalog of all publications available from the Minnesota Geological Survey can be obtained by writing to Minnesota Geological Survey, University of Minnesota, 1633 Eustis Street, St. Paul, Minnesota 55108.

Sample Box of 3 Minerals and 3 Fossils--a free box (3" x 4") containing samples of Minnesota rocks, fossils, and minerals can be obtained by writing to the Minnesota Geological Survey. Because of the limited availability of hand size specimens, only one sample kit can be sent per request.

GUIDE TO MINERAL COLLECTING IN MINNESOTA is a good general source of information on the specific minerals in Minnesota. It is available from the Minnesota Geological Survey for 75¢ plus tax.

GUIDE TO FOSSIL COLLECTING IN MINNESOTA is an equally good book on only the sedimentary rocks and fossils of our state. If you are not interested in these two, you will not need this book. It is available from the Minnesota Geological Survey for 50¢ plus tax.

OTHERS:

Dictionary, college or any other edition;
Encyclopedia (any kind) under subjects or titles;
The Rock Book, Fenton;
Minerals, Pough;
Minnesota Rocks and Waters, G. M. Schwartz and G. A. Thiel. Available from Minnesota Press, 2016 University Avenue S.E., Minneapolis, MN 55414. $7.95.

Household Minerology

This section will introduce you to:

1. the many uses of minerals and metals in your home and
2. the history, mythology, differences, and kinds of birthstones.

Look around you! Observe things in your home! Use your encyclopedia, dictionary, or Golden Book of Rocks & Minerals! Try to find answers to these questions about things and events that happen to you every day.

HOUSEHOLD MINERALS & METALS

1. Name five minerals contained in common household items such as paint, light bulbs, thermometers, etc.

2. Name five metals used in the home.

3. Brass is an alloy consisting of what two metals?

4. Name three rocks used in building.

5. Name three stones used as jewelry.

6. What minerals are good to eat or are necessary in a healthy diet?

7. What stone is used to make Portland cement?

8. What mineral is used to make glass?

9. If you were going to build your own atomic bomb, what rare mineral would you have to find?

10. Name at least two synthetic minerals that man has made.

11. What mineral (not lead) is used in a lead pencil?

12. What lightweight metal is used in cookware?

13. What light-gray metal will buy a candy bar?

14. What black rock of sedimentary origin may be burned to heat the home?

15. What metals are combined to make a good grade of solder?

16. Not all sandpaper is made with silica sand. What other abrasive minerals have been used? Why?

17. What mineral has been introduced into water to reduce tooth decay?

18. What is the hardest rock in your household?

19. What mineral in your household has the greatest unit weight or specific gravity?

20. (Advanced) Name as many rocks, minerals, or metals as you can that are used in making an automobile. Where and how are each used?

BIRTHSTONES

1. Why were gemstones assigned to each month and called "birthstones?"

2. What is the supposed benefit to a person wearing an amethyst?

3. Illustrate the color of each birthstone by drawing a form typical of a cut gem and coloring and labeling it.

4. Illustrate and define a "baroque" gem, a cabachon, and a faceted gem.

5. Why are some stones not suitable for faceting?

6. Name your own birthstone, your parents' birthstones, and the birthstones for your brothers, sisters, or other members of your family.

7. Name at least one place in the world where the 12 birthstones can be found.

Rocks and Minerals

This section explains many new things about rocks and minerals. When completed you should know:

1. That there are many differences in rocks. Each varies in color, hardness, texture or fracture, and lustre.

2. That there are three types of rocks: igneous, sedimentary, and metamorphic.

3. How to identify different rocks and minerals.

4. How to collect, label, and exhibit rocks.

5. The importance of minerals like iron ore, granite, or limestone to the people of Minnesota.

LET'S MAKE A ROCK PLATE

Find four different rocks.

1. One rock should be quartz. It should have a WAXY LUSTRE (quite shiny), and a clear white or other light color.

2. One rock should have a DULL LUSTRE or no lustre. It should be finely granular, green, dull green, gray, or black like basalt.

3. One rock should be granitic. It should be very coarse-grained and may contain pinkish fragments of feldspar.

4. One rock you may select yourself, but report what you can about its lustre. Is it coarse- or fine-grained? What kind of rock do you think it is?

Break the four rocks into small pieces with a hammer and make a solid geometric design on a paper plate. After your design is ready, glue the pieces permanently to the plate with clear-drying cement such as Elmer's Glue-All.

The next three exercises will allow you to begin a collection of rocks and minerals. This will mean that you will be taking some field trips. To prepare for this, please follow the suggestions in "Safety Precautions and Personal Equipment For Field Trips" at the end of this unit. Also read pages 9-10 of your ROCKS & MINERALS handbook or pages 13-15 of GUIDE TO MINERAL COLLECTING IN MINNESOTA. Let's hunt!

EGG CARTON ROCK COLLECTION
(COLLECTION STEP I)

1. Take a field trip to a single exposure (gravel pit, road cut, stream bed) within your county area.

2. Write a report on this trip including a description of the topography (land form) of the hunt area. Tell how you believe your rock specime came to be there.

3. Draw a map detailed enough so that another person your age could find their way from your home to the hunt site.

4. Assemble a collection of 12 rock and/or mineral specimens found on this field trip, and arrange them in a 12-compartment egg carton. Attach a number to each specimen and prepare a card large enough to fit in the top of the egg carton showing the number of each specimen along with the most accurate name you can apply to it. Place your own name and the field location on the bottom of the card.

   REMEMBER: Memory, for even the best of minds, is a fleeting thing. Specimens that are not properly identified and described become just a box of rocks, not a collection.

5. Take as many field trips as you like, and report on each one. Additional material collected may be used in your next collection.

COME SEE MY ROCKS
(COLLECTION STEP II)

Preparing and organizing for a safe and successful field trip will not only produce more and better specimens but a valuable lesson in logistics as well.

1. Prepare for public display at least 24 rocks, minerals, fossils, or any combination of these, all of which you have found somewhere within the state of Minnesota. These are to be either permanently attached (glued) to a substantial backboard 18 x 24 inches or displayed in glass-topped cases of the same size. Plans for this case are outlined in Extension 4-H bulletin #43, "Insects and You." Each individual specimen should be approximately 2 x 2 inches.

2. Prepare individual labels for each specimen giving its name, location where found, type, cleavage, fracture, hardness, texture, and lustre. (See sample label at top of page 7.)

3. Report on at least one field trip outside your county area that is geologically different than your Step I collection. Describe the area's land form and how the collected material came to be there.

4. Give descriptions (a road log), and draw a map so that another person could find the place.

5. Either give a project talk or guide a tour to at least one of your field areas.

6. Visit a rock shop, rock club meeting, or a mineral display in a museum. What was the most outstanding thing you saw or learned?

7. Exhibit your collection at school, in a store window, at a county fair, or on an Achievement Day.

SAMPLE LABEL
(Actual Size)

NAME OF SAMPLE_____

LOCALITY_____

TEXTURE_____ LUSTRE_____ HARDNESS_____

CLEAVAGE_____ FRACTURE_____

TYPE ☐ Igneous ☐ Metamorphic ☐ Sedimentary

ECONOMIC USE_____ SAMPLE NUMBER_____

THEME COLLECTION
(COLLECTION STEP III)

As you become older and more experienced, your rock collection should reflect more and better specimens as well as better mounting and identification.

1. Prepare for public display at least 48 rocks, minerals, or any combination in a single theme such as metamorphism, weathering, quartz minerals, ores, etc. These may be acquired in any way available to the collector (found, traded, purchased). Each specimen should be appropriately labeled and a text included with the exhibit to explain its theme. Size or manner of exhibit is the minimum required to properly present the subject.

2. Visit a mine, quarry, aggregate plant, brick or tile operation, or other facility of economic geology. Explain how the material got there, how it is removed, transported, processed, or manufactured.

SOFT ROCK SPECIAL (Optional)
(COLLECTION STEP IV)

1. Prepare for public display at least 24 fossils, 50 percent of which have been found in Minnesota; the others may have been acquired in any available manner.

2. Make a label card for each specimen giving the class name (such as brachiopod, pelecypod, etc.). Give at least the generic name (such as Strophomena), horizon (such as Decorah shale), and location.

3. Develop a geological time chart of the fossiliferous rock units of your county. Assign dates to the beginning and ending of each of the periods represented.

   Why would you think that geologists refer to sedimentary rocks as "soft rocks?"

The principle source of information for this project will be the GUIDE TO FOSSIL COLLECTING IN MINNESOTA (see book list) and the Golden nature book, FOSSILS, A GUIDE TO PREHISTORIC LIFE.

SIX SILLY SILICATES

In this exercise you will collect and learn about six common Minnesota silicates: crystaline quartz, massive quartz, chert, flint, jasper, and Lake Superior agate. This is another phase of theme collection. Prepare an exhibit of each form of silica explaining the individual differences as well as the similarities of your specimens.

1. CHRYSTALINE QUARTZ, the purest form of silica, is found in the lining of a geode or Lake Superior agate, for example.
2. MASSIVE QUARTZ is transparent and translucent, a white or light color and has a waxy lustre and little or no pattern.
3. CHERT is impure silica, usually vein formed, opaque (not transparent), gray or dirty looking. Oolitic chert appears to have hundreds of tiny spheres, like fish eggs, imbedded in it.
4. FLINT, an impure silica similar to chert but formed in nodules with a whitish crust or rind, is an opaque gray or yellow brown on the inside.
5. JASPER is an impure silica similar to chert or flint but possessing an attractive color or pattern. Minnesota glacial jasper is frequently an egg plant purple with speckels like a bird's egg. It may also be a banded red from the Minnesota iron formation.
6. LAKE SUPERIOR AGATE is vug formed, banded chalcedony, translucent, and usually red or red brown.

IRON ORE PROJECT

A long heritage of iron mining dates back to 1882 when Minnesota's first mine, Soudan iron mine opened. Iron mining has been one of the leading industries in the state. This exercise will give you a chance to learn more about it.

1. Prepare a map of Minnesota showing the name and extent of the three major iron ranges of northern Minnesota.

2. Name or display the various iron, manganese, and other minerals found in each of the three ranges.

3. Where in southern Minnesota has iron been mined? Locate this on your map. What single iron mineral was found there?

4. What good effect has iron mining had on Minnesota?

5. What bad effect has mining had on the mined-out areas of Minnesota?

6. Locate on your map the points at which taconite pellets are manufactured in Minnesota.

7. What ecological problems have arisen from this process?

8. Why is iron smelted in the eastern United States despite the fact that the ore is found here?

9. How is the bulk of the ore transported from Minnesota?

10. Visit the State Park at Tower Soudan, Minnesota, northeast of Virginia on State Highway 169. Visitors to the mine are taken down No. 8 shaft to the 27th level, 2,400 feet below the surface. From there, they are transported to the workings of the Montana Ore Body in the northwestern part of the mine.

11. Visit open pit mines along the Mesabi or Cuyuna range cities of northeastern Minnesota. Open pit mine views are numerous along highway 169 between Grand Rapids and Virginia.

STONE AGE GEOLOGIST

Too much information can take the fun out of life. Try this story for variety.

1. On Saturday night, July 25, 5000 years ago, XYZ tribe of Indians were going to have a dance. The camp was located near what is now Rabbit Lake, Crosby, Minnesota. ABC wanted to do some body painting. His color scheme was red, yellow, brown, and black. What local minerals might be a source for each of these colors?

2. The morning after the dance, ABC was hungry but he had no arrow points to use for hunting. He sent his three children DEF, GHK, and LMN out to find rock suitable for chipping. DEF brought in a big piece of granite, GHK a large slab of sandstone, and LMN three nice chert nodules. Why did DEF and GHK get spanked and sent back to bed?

3. ABC was shown a beautiful pipe carved from a reddish stone from southwestern Minnesota. ABC walked for three days, and where he found the red stone, many other Indians were camped. He asked them the name of their encampment. They told him it didn't have any, so he called it _____.

4. Late one evening ABC was returning home from hunting when a violent storm overtook him. He was so frightened that he crawled into an opening in the earth. When the lightning flashed he saw what appeared to be large icicles of nearly pure calcite hanging from the ceiling and protruding up from the floor of his cave. He didn't know what to call them. What do you call them? How did they get there?

5. ABC sat in front of his tent one hot evening looking at the moon. It looked so cool to him that he said to himself, "some day I will catch a giant bird. I will then pack some venison and a bottle of water and we will fly to the moon." What do you know about the moon that ABC did not?

SELF-DETERMINED PROJECT

You may still want additional challenge in the area of rocks and minerals. As we said earlier, many rocks and minerals are not discussed or mentioned because they are too complex to be considered within this program's scope. We don't want to discourage you from studying and learning about things we have not mentioned. Maybe during these exercises you developed some ideas about an exciting project you would like to develop. Maybe you are interested in the geology of the moon's surface. Maybe you are interested in how silver is mined and made into coins or how commercial fertilizers are manufactured. Maybe you are interested in the relationship of rock formations to geological time and life on earth. Maybe you would like to visit caves. Are you interested in meteors or meteorites, fluorescent minerals, granite, limestone, clay minerals? Here is your opportunity to develop that project.

1. Select a project that appeals to you.

2. Get a qualified person to act as your advisor.

3. Make a work plan.

4. Carry out the work plan (see below).

5. Make a project report.

WORK PLAN

Include:

1. what you intend to do;

2. why you have decided to do it;

3. details of how you expect to do the work;

4. where the work will be done;

5. what the work will produce or find out;

6. what materials are required and their cost;

7. a time-table for getting the work done;

8. what references are required for the study;

9. what photos, models, demonstrations, or exhibits are required; and

10. any change of plans required for the project.

If your county has adopted the Self-Determined Project as part of your 4-H program, ask your county extension office for the following publications:

4-H M-219 "Planning Guide"
4-H M-181 Creating An Exciting Self-Determined Project

SAFETY PRECAUTIONS AND PERSONAL EQUIPMENT FOR FIELD TRIPS

I. Safety Precautions:

a) Avoid overhanging rocks.
b) Keep to base of steep stock piles from old mines.
c) Do not collect directly above or below other collectors on mine dumps (stock piles), hills, etc. One rock cascading to the bottom of a stock pile, hill, or other incline can seriously injure or cripple a person.
d) Keep out of barbed wire enclosures. An old mine shaft several hundred feet deep may be inside this barbed wire enclosure and covered with only old rotten timbers or planks.
e) If a dangerous area is discovered or found, report it to your adult leader or advisor, so that the area will be made safe.
f) Avoid water-filled quarries or gravel pits.
g) Wear safety goggles when chipping with hammer.
h) Wear gloves to avoid cuts from chips and sharp needles.
i) Wear good, sturdy shoes.
j) Always bring at least one first aid kit on a field trip.

II. Other Precautions and Considerations:

a) Respect personal property.
b) Receive permission to enter personal property from owner.
c) Limit your collection of rocks and minerals to only what you need.
d) Handle specimens properly. Some specimens require special handling.
e) Always follow the instructions of your 4-H leader or advisor at meetings and on field trips.

III. Personal Equipment Required for Rock and Mineral Project:

a) Safety goggles.
b) Properly tempered steel hammer to keep chips from flying.
c) Gloves to avoid cuts from chips and needles of rocks and minerals.
d) Good, sturdy shoes preferred.
e) Canteen of drinking water.
f) Club should bring at least one first aid kit on any field trip.
g) A supply of field labels and adhesive tape or masking tape.
h) Shoulder bag or knapsack.

Lapidary Work

Webster's dictionary defines lapidary as a cutter, polisher, or engraver of precious stones or the art of cutting gems. Gems are the most prized and famous of all minerals; diamonds, emeralds, rubies, and sapphires are known to all of us. Other stones are classified as semiprecious and ornamental stones. These will be the basis for this unit in geology.

This unit will give you the opportunity to:

1. Learn about our state stone, the Lake Superior agate.

2. Learn that differences exist among semiprecious gem stones.

3. Learn how to build an inexpensive tumbler and how to use it to polish stones.

4. Learn how to create decorative items (jewelry, paperweights, etc.) from these polished stones.

THE STATE STONE

The state stone for Minnesota is the Lake Superior agate.

1. Show a banded or fortification Superior agate.

2. Show a specimen with quartz bands or a quartz heart (center).

3. Show a specimen with amethyst-tipped quartz inclusions or a specimen with other inclusions or foreign substances.

4. Show a specimen with well developed "eyes" on the exterior hull.

5. Show an extensive range of colors in this agate.

6. What mineral is the Lake Superior agate made of?

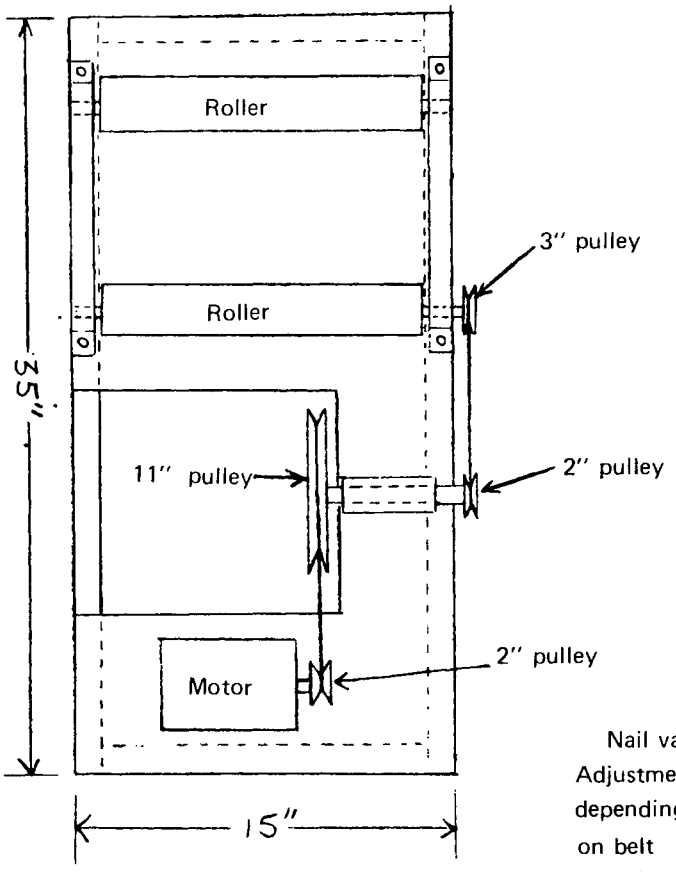
7. Was the Lake Superior agate made in Minnesota?

MAKING A ROCK TUMBLER

If you are interested in lapidary work, one tool you will need is a tumbler. Many kinds are available today, but if you want to make your own, plans are included on page 14. All you need are some old spare parts, some lumber, and an electric motor, and you're in business. There are some problems in making a tumbler that you should realize.

- You must get a metal rock-filled container to revolve continuously at a rate of not more than 30 revolutions per minute.
- If speeds over 30 RPM are maintained, the mass within the barrel will pitch over and the stones will show "peening" or impact marks.
- You must reduce the speed of an electric motor from 3750 RPM to 30 RPM on the roller through a step-down system of pulleys.
- You must drive the barrel by having it ride on a pair of rollers, such as old washing machine wringer rollers or ½" pipe covered with neoprene garden hose. Lateral movement is controlled by a centering arm.
- You must make a leakproof barrel capable of traveling continuously on the rollers. This barrel should be lined with sheet rubber similar to old tire inner tubes. It may be cemented to the sides with contact cement like "weldwood." The barrel may be a durable gallon can or 8" section of well casing with wooden ends.
- The oak block bearings for the rollers should be drilled slightly larger than the roller shaft. If lubricated, they will run cool and quiet. At 30 RPM, little heat or wear will occur.

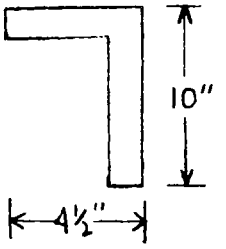
Any practical way of solving the above problems is acceptable. If solutions are impossible, you may want to buy a tumbler.



TOP VIEW

CENTERING ARM (make 2)

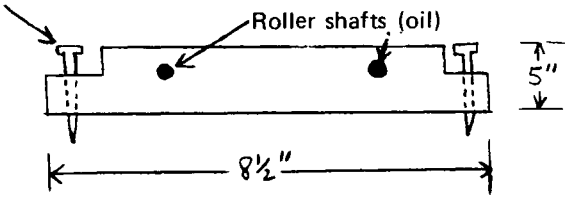
DETAIL A



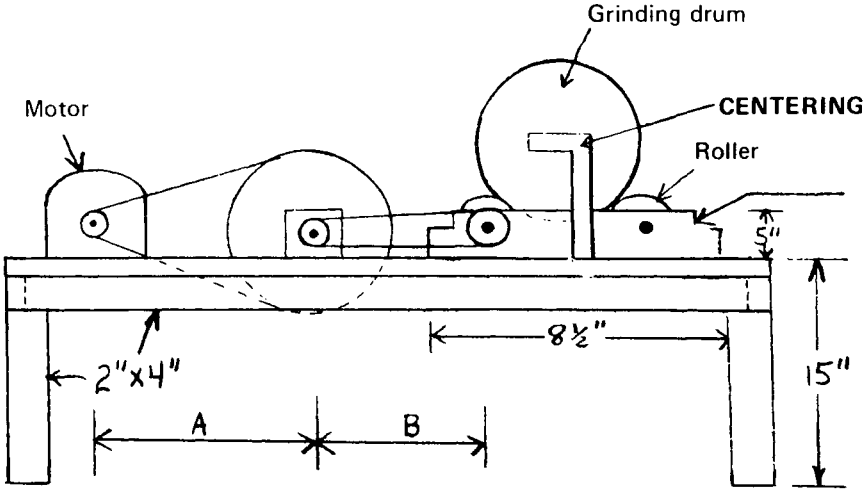
Nail variable Adjustment depending on belt length

PILLOW BLOCK (1" oak)

DETAIL B



SIDE VIEW



Distance A and B will vary depending on length of belts.

TECHNIQUES OF TUMBLING

ROUGH GRIND - Stones should average 3/4". No stone in a small tumbler should be over 1¼". Fill barrel about 60 percent full. Add soft water (or one teaspoon of soda to hard water). Water level should be just below stone level. Add ½ pound number 80 silicon carbide grit and 1 teaspoon of powdered (not liquid) detergent for each 6 pounds of stone. The foaming detergent holds the grit in suspension so that it will cut all the stones. Run this load the equivalent of 1 full week.

SECOND GRIND - Remove and wash both the stones and the barrel. The stones should be well rounded by now. If they are not, they must be rough ground again. Sort through and eliminate stones that may not be worth further working. Reload tumbler using number 220 silicon carbide grit, water, and detergent as per rough grind formula. This finer abrasive will remove the coarse scratches left by the rough grind and will prepare the surface for the finish. Run the equivalent of 1 full week.

THIRD GRIND - Wash stones and barrel again. Repeat the formula but this time use number 600 silicon carbide grit. Run hard materials at least 8 days. Softer materials may cut down in less time. You may open the tumbler and examine the stones if necessary. At the completion of this grind, the stones have a silky smooth surface.

PREPARING FOR POLISH - Wash stones and barrel so that both are completely free of grit. Return stones to barrel; add water and ½ cup of powdered detergent (no grit). Run overnight (8-10 hours). Your stones are now clean.

POLISH - Wash out tumbler and stones. Cover with fresh soft water, ½ cup of detergent, and 1 level teaspoon of either Norton's E-266 polish or cesium oxide or tin oxide, titanium oxide, or other acceptable polishing agent. More polish will do a poorer, not better, job. If the volume of the rock load has fallen below 60 percent, bring it up by adding either small stones that have already been polished, plastic pellets, wood chips, or nut shells. It is now important that the barrel be exactly 60 percent full. A 5- to 7-day run should complete the polish. Remove and wash the stones and barrel. Run the stones overnight in soft water and ½ cup of Fels Naptha or other soap (not detergent) flakes. Empty, wash, and then buff the mass of stones with a towel.

SORT AND GRADE - Sort and grade each individual stone. Many types of stones will polish. This is the moment of truth. If you have put junk into the tumbler, that is what will come out. Most stones should make you happy; some may be worth re-grinding. Others should be thrown away or used later in the polishing aggregate. You are ready now to make jewelry.

EXERCISES

1. Describe in a demonstration or project talk how you made your tumbler.
2. What have you learned about tumbling?
3. How do you plan to use your tumbled stones?
4. Teach someone else how to construct a tumbler.
5. Make some jewelry.

Demonstrations

Share what you have learned with others in your project group or 4-H club by giving a demonstration or project talk. It will be good practice in expressing yourself and giving you confidence to perform before a group of your friends.

Here are some topics for you to consider:

Glaciation in Minnesota,
How the earth was formed,
How rocks are formed,
Cutting agates,
Polishing agates,
Making jewelry,
Agate formation,
Elements and their various uses,
Chemical combinations in formation of colors,
How to polish,
Where to find the different types of stones,
What different kinds of stones are good for,
How to distinguish one stone from another,
What stone can be used for,
The place of stones in our environment,
How to prepare an exhibit for the fair,
How to prepare a rock display box,
Defining a geode,
How geodes are formed and where they are found,
Cutting a geode,
Face polishing a geode or slab,
The scratch method of identifying stones,
Demonstrate the workings of the Mohs Hardness Scale, and
Illustrate cleavage and crystal formation.

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